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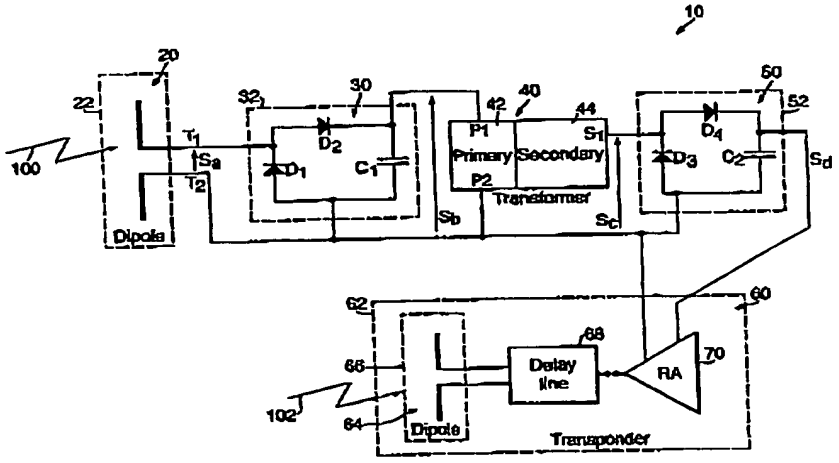

(57) Abstract: The invention provides a piezo-electric tag (10, 300) in the form of a card, the tag (10, 300) incorporating a first dipole antenna (20), a first rectification circuit (30), a piezo-electric transformer (40), a second rectification circuit (50) and a transponder circuit (60). In operation, the antenna (20) receives incoming radiation and generates a corresponding signal S_a which propagates to the first circuit (30) which demodulates and filters it to generate a signal S_b. The signal S_b is applied to the transformer (40) to excite it. The transformer (40) increases the voltage amplitude of the signal S_b by generating a relatively higher voltage amplitude signal S_c which is used in the tag (10, 300) to generate a signal S_d for supplying power to the transponder (60). The transformer (40) provides voltage magnitude enhancement to generate potentials suitable for operating active electronic circuits incorporated into the tag (10, 300). The tag can be personnel wearable and even adapted for permanent inclusion into biological systems.

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PIEZO-ELECTRIC TAG

The present invention relates to a piezo-electric tag.

Tags are portable devices which are capable of being attached to items or personnel wearable. They can be used, for example, for remotely identifying the items or receiving information therefrom. In many applications, the tags must be compact and be capable of responding after long periods of inactivity, for example where the tags are incorporated into items placed into storage for periods of several years.

Conventionally, tags can be passive devices which modify and reflect interrogating radiation directed thereto from associated interrogating sources. Because the tags do not provide power gain, their operating range from the sources is often limited to a few metres.

Active tags are known which incorporate onboard power sources such as a miniature electrical cell. Such power sources have limited operating lifetime, especially if they are required to power their associated tags continuously. Moreover, the sources can make the tags unacceptably bulky for some applications, for example where tags are implemented as film strips for incorporating into spines of library books.

Although it is feasible to power tags from radiation incident thereupon, for example using solar cells incorporated into the tags or by inductively coupling energy from associated interrogating sources to the tags, it is not practicable in some circumstances to do this for safety reasons, for reasons of restricted operating range or for reasons of obscuration in the case of solar cells.

The use of received radio radiation for powering electronic tags is known in the art, for example as disclosed in a published patent application no. GB 2 306 081A. In the application, there is described a passive electrical power supply for providing electrical power to an electronic tag, the supply comprising an antenna for converting received radio frequency radiation into a first electrical signal, and a transformer including wire-wound coils for transforming the first signal into a second signal capable of altering the impedance of a field effect transistor (FET). In operation, the FET provides at its drain electrode a quasi half-wave rectified representation of the second signal which is converted to a unipolar signal by a capacitor connected to the drain electrode, the unipolar signal providing a power supply potential for operating the tag. The supply is operable to convert the received radiation into the unipolar signal such that the transformer operates at the frequency of the received radiation received at the antenna. The transformer can optionally be an autotransformer comprising a single wire-wound coil.

A power supply for a transponder is also disclosed in a published patent application no. GB 2 303 767 A. The supply described provides power to a response circuit of the transponder, the supply generating direct current (d.c.) from received electromagnetic energy. The supply comprises a capacitor charged from a rectifier diode, the diode having a characteristic such that its reverse resistance against a reverse current directed at its n region to its p region is lower than its forward resistance against a reverse current directed from its p region to its n region. The diode is thus connected reversely compared to a conventional diode, its anode being connected to a positive plate of the capacitor. The arrangement allows the transponder to remain functional even when the received electromagnetic energy is relatively weak. The required characteristic for the diode can be implemented by the avalanche or tunnel effect. Moreover, a voltage multiplier may be provided by using a plurality of the diodes with

associated capacitors for generating higher supply potentials. The supply does not employ any form of transformer for increasing the potential of signals generated in response to receiving the electromagnetic energy.

Piezo-electric transformers capable of stepping up potentials are also known in the art, for example as described in US patent nos. US 5 828 160 and US 5 389 852. Such transformers are operable to resonate at a frequency typically in a range of several tens of kHz to 300 kHz when stepping up potentials. This range of frequencies is considerably less than that used for electromagnetic radiation conventionally employed to interrogate electronic tags, for example 10 MHz to 30 GHz. Although piezo-electric transformers operating at frequencies above 300 kHz can be fabricated, for example 600 kHz, their cost and difficulty of fabrication renders them unattractive for items such as electronic tags.

Non-contact energy coupling schemes employing piezo-electric devices are known in other technical fields, for example as disclosed in a US patent no. 5 749 909 concerning medically implanted devices. In the patent, there is described an energy transmission system for transmitting energy non-invasively from an external unit to an implanted medical device to recharge a battery in the medical device. An alternating magnetic field is generated by the external unit and a piezo-electric device in the implanted medical device vibrates in response to the magnetic flux to generate a voltage. The voltage is rectified and regulated to provide charging current to a rechargeable battery in the medical device. In the arrangement, the piezo-electric device is stimulated by the magnetic flux at a resonant frequency of the device, namely in the order of tens of kHz.

The inventor has appreciated that a principal problem associated with tags operated from radiation incident thereupon is that it is difficult to generate potentials on the tags of sufficient magnitude to operate semiconductor integrated circuits incorporated therein. Such circuits frequently require a supply potential a several volts to function.

The inventor has devised a tag which addresses this principal problem and which is operable, for example, from moderate levels of incident radiation thereupon in the order of 10 μW. Such moderate levels of radiation rarely represent any health and safety risk.

According to a first aspect of the present invention, there is provided a piezo-electric tag including receiving means for receiving input radiation and generating a corresponding received signal, piezo-electric vibrating means for increasing voltage magnitude of the received signal to generate a supply potential and electronic circuit means powerable by the supply potential.

The invention provides the advantage that the vibrating means is capable of providing voltage magnification, thereby enabling the tag to be powered from radiation incident thereupon.

For the purpose of describing the invention, microwave frequencies means frequencies substantially in a range of 1 GHz to 30 GHz.

Advantageously, the vibrating means comprises a piezo-electric transformer incorporating mutually vibrationally coupled primary and secondary regions, the transformer operable to be excited into vibration by the received signal at the primary region and to generate a

corresponding output signal at the secondary region for use in generating the supply potential.

The piezo-electric transformer provides the advantage that it is capable of being compact, inexpensive and providing a considerable increase in signal voltage amplitude from its primary region to its secondary region, the increase approaching 100 times or more.

Alternatively, the vibrating means comprises a piezo-electric bi-morph operable to be excited into vibration by the received signal and to generate a corresponding output signal for use in generating the supply potential.

As a further alternative, the vibrating means conveniently comprises a silicon micromachined device comprising an array of one or more resonant elements, each element incorporating an associated piezo-electric transducer operable to generate an element signal in response to vibration of its associated element, the transducers connected in series to add their element signals to provide an overall output from which the supply potential is generated, and driving means operable to be driven by the received signal for stimulating the one or more elements into vibration and thereby generating the supply potential.

The silicon device provides the advantage that it capable of being mass-produced and being highly compact, for example 2 mm wide by 2 mm long by 0.6 mm thick.

Advantageously, the resonant elements in the silicon device are operable at resonance to generate the supply potential. Operation at resonance provides the benefit that voltage magnification in the device is greater than off-resonance.

Moreover, to obtain even greater voltage magnification, the resonant elements are housed in an evacuated environment. Operation in the evacuated environment increases Q-factor of the resonant elements, thereby increasing voltage magnification provided by the silicon device.

Conveniently, the receiving means in the tag incorporates demodulating means for demodulating modulation components present in the received radiation to generate the received signal. Inclusion of the demodulating means provides the benefit of signal frequency transformation, thereby enabling the tag to receive radiation providing power thereto at a different carrier frequency to the frequency of vibration required for exciting the vibrating means.

Advantageously, the demodulating means incorporates zero-bias Schottky diodes for demodulating the received radiation to generate the received signal. The zero-bias Schottky diodes provide the advantage of exhibiting a smaller forward conduction voltage drop compared to p-n silicon junction diodes, thereby enabling the tag to function with lower levels of received radiation power, for example 10 μW.

Conveniently, the receiving means incorporates one or more conductive metallic film dipole antennae for one or more of receiving and emitting radiation. Such dipoles provide the advantage of being potentially compact and inexpensive to mass-produce.

The tag beneficially incorporates two antennae, one antenna for use in generating the received signal and the other incorporated into the responding means for at least one of emitting and receiving radiation. Incorporating two antennae provides the advantage that

each antennae can be optimized to function at its respective radiation frequency. Conveniently, the antennae are conductive metallic film dipole antennae for reasons of increased compactness and reduced manufacturing cost. Alternatively, the antennae can also be patch antennae or loop antennae.

In some practical applications of the tag, it is advantageous that the tag is implemented in the form of a block, for example a cuboid block. This form provides the tag with enhanced mechanical robustness and thereby increases its reliability.

When the tag is personnel wearable or attachable to items of merchandise, it is convenient that the tag is in the form of a planar card. This form provides the advantage that the tag can be of similar size to existing planar cards, for example debit cards, thereby providing a degree of potential compatibility with existing card reading equipment.

When the tag is implemented in a planar card form, it conveniently incorporates recesses for accommodating the receiving means, the vibrating means and the responding means. Such recesses provide protection for the receiving means and the responding means, thereby making the tag more robust.

In the tag, the circuit means can comprises responding means for emitting output radiation from the tag, the responding means powerable by the supply potential. Incorporation of the responding means enables the tag to be remotely identified when interrogated.

Conveniently, the responding means is a transponder operable to receive input radiation to the tag and emit output radiation in response from the tag. Incorporation of the transponder

enables the tag to be selectively responsive to interrogating radiation in an environment which is flood illuminated with radiation for exciting the vibrating means.

Advantageously, the transponder is operable to modulate the output radiation with a signature code by which the tag can be individually identified. The code enables the tag to be individually recognised which is highly advantageous where the tag is personnel wearable and used to identify its wearer, for example as in personal identification tags worn by employees in a commercial establishment.

When operating with high frequency radiation, for example at UHF frequencies from 300 MHz to 1 GHz and from microwave frequencies from 1 GHz to 30 GHz, the tag advantageously has the transponder incorporating a reflection amplifier for amplifying the input radiation to generate the output radiation. The reflection amplifier provides the advantage that it is capable of providing a high gain, for example in a range of +10 dB to +30 dB, for relatively low current consumption, for example in the order of a few microamperes.

Advantageously, especially when the transponder provides considerable gain, the transponder is operable in a pseudo-continuous mode and incorporates a delay line for delaying the output radiation relative to the input radiation, thereby counteracting spontaneous oscillation from arising within the transponder from feedback therein.

Conveniently, the tag is arranged such that the receiving means incorporates first and second antennae for generating the received signal for exciting the vibrating means, the first antenna adapted to respond to microwave radiation and the second antenna adapted to respond to

radiation having a carrier frequency corresponding to a resonant frequency of the vibrating means. Incorporation of two antennae for generating the received signal provides the advantage that the tag is powerable from radiation having a number of possible carrier frequencies.

In a second aspect of the invention, there is provided a method of guiding a vehicle along a path to a destination, the method comprising the steps of:

(a) distributing a plurality of tags according to the first aspect along the path and providing the vehicle with a direction sensitive interrogating source adapted to transpond with the tags;

(b) interrogating the tags from the source by emitting radiation to the tags and receiving radiation therefrom, thereby determining direction of the tags relative to the source and hence determining the path;

(c) moving the vehicle along the path; and

(d) repeating steps (b) and (c) until the vehicle reaches the destination.

Embodiments of the invention will now be described, by way of example only, with reference to the following diagrams in which:

Figure 1 is a schematic of a first embodiment of the invention;

Figure 2 is an exterior perspective view of the first embodiment shown in Figure 1;

Figure 3 is an illustration of a second embodiment of the invention;

Figure 4 is an illustration of a third embodiment of the invention incorporating a simplified circuit utilising loop antennae;

Figure 5 is an illustration of a fourth embodiment of the invention adapted for operating with Manchester encoded signals; and

Figure 6 is an illustration of a fifth embodiment of the invention incorporating a single antenna for use in emitting and receiving radiation.

Referring to Figure 1, there is shown a piezo-electric tag according to a first embodiment of the invention indicated by 10. The tag 10 incorporates a number of sections, namely a first dipole antenna indicated by 20 and included within a dotted line 22, a first rectification circuit indicated by 30 and included within a dotted line 32, a piezo-electric transformer indicated by 40 incorporating a primary region 42 and a secondary region 44, a second rectification circuit indicated by 50 and included within a dotted line 52, and a transponder circuit indicated by 60 and included within a dotted line 62. The sections are incorporated into a plastic card having external dimensions of 55 mm width, 85 mm length and 1 mm thickness; this will be further described later with reference to Figure 2.

The transponder 60 incorporates a dipole antenna indicated by 64 and included within a dotted line 66, a bi-directional surface acoustic wave (SAW) delay line 68 and a reflection amplifier 70.

The first dipole antenna 20 is connected to an input of the first rectification circuit 30. The circuit 30 includes an output which is connected to the primary region 42 of the transformer 40. The secondary region 44 thereof is connected to an input of the second rectification

circuit 50. The second circuit 50 incorporates an output which is connected to a power supply input to the transponder 60.

Operation of the tag 10 will now be described in broad overview after which its sections will be described in further detail.

The antenna 20 receives incoming radiation 100 from an interrogating source (not shown). The radiation 100 has a carrier frequency of 1 GHz which is amplitude modulated to a modulation depth in a range of 50% to 100% by a modulating signal which has a frequency of 300 kHz. Moreover, the radiation 100 has a power density of 5 mW/m^2 at the antenna 20. The radiation 100 couples to the antenna 20 and generates a corresponding signal S_a across output terminals T_1, T_2 of the antenna 20; the signal S_a has a frequency of 1 GHz and an amplitude in the order of 80 mV. The signal S_a propagates to the first circuit 30 which demodulates it and then filters it to substantially remove signal components above 1 MHz to generate a unipolar modulated signal S_b having signal components at 300 kHz. The transformer 40 receives the signal S_b across its primary region terminals P_1, P_2. The signal S_b stimulates the primary and secondary regions 42, 44 to resonate at 300 kHz in their longitudinal mode of vibration. At resonance, the transformer 40 magnifies the signal S_b received at its primary region 42 to generate a bipolar alternating signal S_c at a secondary region terminal S_1, the signal S_c having an amplitude in the order of 3 volts. The second circuit 50 receives the signal S_c and demodulates and filters it to generate a substantially smoothed unipolar signal S_d at an output terminal of the circuit 50. The transponder 60 receives the signal S_d and uses it as a supply potential to power active circuits incorporated thereinto.

The transformer 40 provides the advantage of performing a step-up voltage conversion

function from its primary region 42 to its secondary region 44 at resonance, thereby providing the signal S_d of sufficient magnitude of several volts to power active electronic devices incorporated into the transponder 60, namely the reflection amplifier 70. Although the transformer 40 cannot provide power gain, it is effective to provide an impedance conversion for matching an input impedance presented by the second circuit 50 to an output impedance presented by the first circuit 30; the signal S_a of relatively lower voltage amplitude from the antenna 20 which is unsuitable for powering circuits is thereby converted into the signal S_d of relatively high voltage, namely several volts, which is suitable for powering circuits.

The transponder 60 receives incoming continuous-wave radiation 102 from the interrogating source. The radiation 102 has a carrier frequency of 1.5 GHz. In response to receiving the radiation 102, the antenna 64 generates a corresponding signal S_e at its terminals which passes to the delay line 68 and propagates therethrough whilst being delayed therein to provide a signal S_f at an input to the reflection amplifier 70. The amplifier 70 presents a modulated negative resistance at its input/output terminal and thereby reflectively amplifies the signal S_f to generate a corresponding modulated amplified signal S_g. The signal S_g propagates back through the delay line 68 whilst being delayed therein to the antenna 64 from where it is emitted as return radiation. The interrogating source receives the return radiation and determines that it is modulated, thereby detecting the presence of the tag 10.

The tag 10 provides the benefit that it is capable of providing the modulated return radiation without there being a need for the tag 10 to incorporate limited lifetime power sources such as batteries for powering its active circuits. Avoidance of the need for batteries provides the tag 10 with a potentially useable lifetime of several decades or more. Thus, the tag 10 is

thereby suitable for attachment to products which are to be stored for lengthy periods of time, for example several years.

Sections of the tag 10 will now be described in more detail.

The antenna 20 is a thin film dipole formed by conductive tracks on a major surface of the card. It is designed to operate at a radiation frequency of 1 GHz. The terminal T_2 of the antenna 20 is connected to a signal ground on the card, and the terminal T_1 is connected to the first circuit 30.

The circuit 30 incorporates two zero-bias Schottky diodes D_1, D_2 and a filter capacitor C_1. The diode D_2 is connected by its anode to the diode D_1 at its cathode to form an input terminal; the terminal is connected to the terminal T_1 of the antenna 20. The diode D_2 is connected at its cathode to a first terminal of the capacitor C_1. The capacitor C_1 incorporates a second terminal which is connected to the signal ground. The diode D_1 incorporates an anode which is also connected to the signal ground.

The diodes D_1, D_2 are operable to provide signal rectification at microwave frequencies, for example 1 GHz, and be responsive to signal amplitudes in the order of mV. They incorporate metal-semiconductor junctions for performing rectification. Ordinary p-n silicon junction diodes are not as desirable for use in substitution for the diodes D_1, D_2 because of their relatively greater voltage drop when operating under forward bias. The capacitor C_1 is operable to shunt signal components at microwave frequencies to the signal ground. An output from the circuit 30 is extracted from across the capacitor C_1, namely from the first terminal of the capacitor C_1 relative to the signal ground.

The transformer 40 is fabricated from a hard piezoelectric lead zirconate titanate (PZT) material whose dielectric loss coefficient is less than 0.02; the dielectric loss coefficient is defined as a ratio of energy dissipated per cycle to energy stored per cycle. It has exterior dimensions of 3 mm width, 6 mm length and 1 mm thickness and is therefore of an elongate form having an elongate axis. In operation, it is designed to periodically vibrate in a longitudinal manner along the elongate axis at a resonant frequency of approximately 300 kHz. The primary region 42 comprises a multilayer stack of piezoelectric elements, each element having exterior dimensions of 3 mm length, 3 mm width and 0.1 mm thickness and polarised in its thickness direction. The secondary region 44 comprises a single element having exterior dimensions of 3 mm width, 3 mm length and 1 mm thickness; the region 44 is polarised in a direction parallel to the elongate axis when assembled in the transformer 40. The elements of the primary region 42 and the second region 44 are mutually joined by sintering them together or using an epoxy resin of comparable rigidity to the PZT material.

In operation, the transformer 40 exhibits a longitudinal resonance mode at 300 kHz frequency having an associated Q-factor in the order of 100. It functions at its resonance to magnify the voltage amplitude of signals applied to its primary region 42 by generating corresponding signals at its secondary region 44 of relatively greater voltage amplitude. This magnification arises at the expense of reduced signal current at the secondary region 44 compared to the primary region 42; in other words, the transformer 40 provides an impedance match but does not impart power gain.

The circuit 50 employs an identical configuration to the circuit 30. The capacitor C_1 and the diodes D_1, D_2 in the circuit 30 correspond to a capacitor C_2 and diodes D_3, D_4 in the

circuit 50 respectively.

The reflection amplifier 70 of the transponder 60 is connected at its power supply connections to the signal ground and to the first terminal of the capacitor C_2 which is not connected to the signal ground. Electrical power is thereby supplied to the amplifier 70 in operation.

The reflection amplifier 70 incorporates a switching oscillator which periodically switches reflective gain provided by the amplifier 70 between a high gain state and a low gain state. The oscillator is operable to switch the amplifier 70 in a cyclical manner between the high gain state for a period of 2τ and the low gain state for a period of 2τ. In the low gain state, the amplifier 70 is incapable of sustaining spontaneous oscillation within the transponder 60. The period of 2τ corresponds to twice a time duration for signals to propagate in one direction through the delay line 68. Periodic switching of gain provided by the amplifier 70 counteracts the formation of spontaneous oscillation within the transponder 60 because amplified signals from the amplifier 70 are reflected from the antenna 64 and return to the amplifier 70 when it is switched to its low gain state. In its high gain state, the amplifier 70 provides +23 dB gain which could result in the formation of spontaneous oscillation if the amplifier 70 were not periodically gain switched to the lower gain state as described above.

Referring now to Figure 2, there is provided an exterior perspective illustration of the tag 10. The tag 10 incorporates a non-conducting plastic substrate layer 200 having first and second major faces. Onto the first major face is bonded a conductive earth-plane layer 210 of aluminium material in a range of 30 μm to 100 μm thick. The layers 200, 210 have a length of 85 mm in an x-direction indicated by an arrow 212, and a width of 55 mm in a y-

direction indicated by an arrow 214. The layers 200, 210 have a combined thickness of 1 mm in a z-direction indicated by an arrow 216.

The substrate layer 200 incorporates recesses 230, 240, 250, 260 moulded thereinto to accommodate the circuits 30, 50, the transformer 40, the amplifier 70 and the delay line 68 respectively. Being elongate, the tag 10 has an elongate axis in the x-direction. At first and second elongate ends of the tag 10, there are formed the antennae 20, 64 respectively. The antennae 20, 64 are both bow-tie dipole antennae incorporating deposited metallic regions formed onto the second major face of the layer 200. Connecting conductive tracks are also formed on the second major face to connect the antennae 20, 64 to the circuits 30, 50 and the delay line 68 respectively. Further tracks are included to connect the circuits 30, 50 to the transformer 40 and the amplifier 70, and the delay line 68 to the amplifier 70. Wire bonding techniques are employed for bonding from the tracks to the recesses 230, 240, 250, 260.

When fabricated, a 100 μm thick protective plastic layer (not shown) is added onto the second major face to protect the antennae 20, 64, the tracking, the circuits 30, 50, the transformer 40, the amplifier 70 and the delay line 68. Graphical information, for example optically readable bar codes or a photographic image, can be optionally printed onto the protective layer. The photographic image is particularly relevant when the tag 10 is personnel wearable and used as a remotely interrogatable identity tag.

Referring now to Figure 3, there is shown a piezoelectric tag according to a second embodiment of the invention indicated by 300. The tag 300 is identical to the tag 10 except that it additionally includes a planar coil 310 in parallel connection with the capacitor C_1.

The earth plane layer 210 can be selectively absent in a vicinity of the coil 310 so as not to excessively screen the coil 310. The coil 310 is formed onto the second major face of the layer 200 shown in Figure 2 adjacent to the circuits 30, 50 and the transformer 40. The capacitor C_1, in parallel with an electrical capacitance presented by the transformer 40 between its terminals P_1, P_2, and the coil 320 are operable to parallel resonate at the resonant frequency of the transformer 40, namely 300 kHz. Inclusion of the coil 320 enables the tag 300 to be powered not only from 1 GHz radiation received at the antenna 20 but also from inductively coupled magnetic fields at 300 kHz coupling to the coil 320. The tag 300 can thereby be powered in two different modes so that it can be used in environments where radiation at either or both frequencies, 300 kHz and 1 GHz, are present; for example, in environments where microwave radiation cannot be tolerated for safety reasons.

As an alternative to using the diodes D1 to D4 in the tags 10, 300, FETs functioning as asynchronous detectors may be employed. FETS operating in this mode exhibit a voltage drop thereacross in the order of microvolts.

Moreover, the antennae 20, 64 may be substituted by a single patch antenna or a single loop antenna operable to receive and emit radiation and convey signals to the circuit 30, and to and from the delay line 68. Although the tags 10, 300 are described as being receptive and emissive at radiation frequencies of 1 GHz and 1.5 GHz, they can be operated at other microwave frequencies by modifying dimensions of features of the antennae 20, 64 and the delay line 68. At microwave frequencies in excess of 10 GHz, the delay line 68 is advantageously replaced by a magnetostatic wave delay line (MWDL), for example a delay line incorporating a film of yttrium iron garnet (YIG) providing a signal propagation path in the delay line.

Furthermore, the tags 10, 300 can be modified by replacing the transponder 60 with, for example, a simple oscillator emitting through its antenna encoded radiation unique to the oscillator, thereby enabling the tags 10, 300 when modified to be uniquely identified from the radiation emitted therefrom. Additionally, the transponder 60 can be operable to emit radiation during a first period and be inactive during a second period, the transponder arranged to switch cyclically between the first and second period; this provides the advantage that the transponder 60 can respond by emitting bursts of relatively more powerful radiation during the first period and conserve energy during the second period.

Referring now to Figure 4, is an illustration of a piezo-electric tag indicated by 400 which incorporates a simplified circuit utilising a first loop antenna 410 for receiving radiation, a transmitter module (TX) 420 and a second loop antenna 430 for emitting radiation. The tag 400 further comprises the transformer 40 and the second rectification circuit 50. In a similar manner to the tags 10, 300, the tag 400 is powered from radiation incident thereupon.

The antenna 410 includes first and second connections, the first connection connected to a signal earth plane of the tag 400 and the second connection connected to the terminal P_1 of the transformer 40. The terminal P_2 of the transformer 40 is connected to the signal earth plane. The terminal S_1 of the transformer 40 is connected to the circuit 50, and the output from the circuit 50 is connected to a V_S power input of a pulsed transmitter 420. The transmitter 420 is also connected to the signal earth plane. Moreover, the transmitter 420 includes an output Q which is connected to a first connection of the antenna 430. A second connection of the antenna 430 is connected to the signal earth plane.

The antenna 410 provides an inductance at its connections which is arranged to electrically resonate with a capacitance exhibited by the transformer 40 across its terminals P_1, P_2 at a frequency corresponding to input radiation to the tag 400 and also to a vibrational mode of the transformer 40 when functioning to increasing signal voltage from its primary region to its secondary region. The transmitter 420 incorporates a transistor biased into class C mode of operation such that it only conducts for part of a signal cycle when functional when an output from the circuit 50 to the transmitter 420 exceeds a threshold value. When the output from the circuit 50 is less than the threshold value, the transistor is non-conducting, thereby conserving power and providing the circuit 50 with maximum opportunity to develop a potential.

Operation of the tag 400 will now be described with reference to Figure 4. The antenna 410 receives radiation incident on the tag 400 at a frequency of 300 kHz and provides a 300 kHz signal across the terminals P_1, P_2 which excites the transformer 40 into resonance. The transformer 40 provides a voltage stepped-up signal at a frequency of 300 kHz at its secondary terminal S_1. The signal passes to the circuit 50 which rectifies it to provide a d.c. potential across the capacitor C_2. This potential is supplied to the transmitter 420 at its V_s power input. When the potential exceeds a value of 2 volts relative to the signal earth, the transmitter 420 becomes active and generates at its output Q an output signal in the form of bursts of signal, each burst comprising a sequence of 500 kHz pulses, each burst having a duration of 50 μsec and the bursts having a repetition rate of 2 Hz. The output signal couples from the transmitter 420 to the antenna 430 from where it is emitted as radiation.

The tag 400 provides the advantage that it is simpler and potentially cheaper to manufacture than the tags 10, 300. When the tag 400 is manufactured in volume, the transmitter 420 of

each tag 400 can be customized to generate bursts of 500 kHz radiation at a repetition rate unique to the tag 420, thereby distinguishing it from other tags of identical design. Class C operation provides the advantage that the transistor does not consume power until radiation above a threshold amplitude is received at the tag 400 which causes the transistor to be driven into an active region of its characteristics.

Modifications can be made to the tag 400 without departing from the scope of the invention. For example, the transformer 40 can be replaced by a piezo-electric vibrating bi-morph or a silicon micromachined vibrating structure capable of providing an increased signal voltage at its secondary region relative to its primary region.

Referring now to Figure 5, there is shown a tag indicated by 500 for operating with Manchester bi-phase encoded signals. The tag 500 comprises the antenna 20, the circuits 30, 50, and the transformer 40. It further comprises a logic unit 510 and a transmitter 520 linked to a loop antenna 530. The antenna 20 is connected to the circuit 30 which is in turn connected to the transformer 40 and then to the circuit 50 in an identical manner to the tag 10. An output from the circuit 50 generated across the capacitor C_2 is connected to the logic unit 510 and the transmitter 520. Inputs Clk and "Data input" of the unit 510 are connected to the terminals S_1 and P_1 of the transformer 40 respectively.

The unit 510 incorporates an output D_o which is connected to an input D_i of the transmitter 520. The transmitter 520 includes an output U which is connected to one connection of the antenna 530; another connection of the antenna 530 is connected to a signal earth of the tag 500.

A Manchester bi-phase encoded signal M will now be described. A digital data signal D has two states corresponding to logic 0 and logic 1. The signal D switches between these two states to convey a stream of data comprising 0's and 1's. The signal D remains in either of the two states for periods of not less than 2τ where τ is a time constant. The signal D is then exclusive-ORed with a clock signal K having a frequency of $^1/_{2\tau}$ to generate the signal M. The advantage of the Manchester bi-phase signal is that it is constantly changing even when the signal D is in a constant 0 or 1 state.

Operation of the tag 500 will now be described decoding the signal M. Radiation having a carrier frequency of 1 GHz and modulated by the signal M is received at the antenna 20 which generates a corresponding 1 GHz modulated signal. The circuit 30 demodulates the 1 GHz signal to generate the signal M at the terminal P_1 of the transformer 40. The clock signal K is arranged to have a principal frequency component corresponding to a resonance mode of the transformer 40 at which it provides voltage increase from its primary region 42 to its secondary region 44. Because the transformer 40 exhibits a relatively narrow resonance peak, it is effective at stripping out the signal D from the signal M to output predominantly the signal K at the terminal S_1. The signal at the terminal S_1 then passes to the circuit 50 which rectifies it to generate a d.c. potential across the capacitor C_2. The potential passes to power supply inputs V_s of the unit 510 and the transmitter 520 to apply power thereto. The signal M present at the terminal P1 and the signal K present at the terminal S_1 are also conveyed to the inputs Clk and "Data input" respectively of the unit 510 which performs an exclusive-OR function to recover the signal D which is then output at the output D_o. The signal D propagates from the unit 510 to the transmitter 520 which is controlled by data conveyed in the signal D. The transmitter 520 responds to the data by emitting modulated 1 MHz radiation from the antenna 530.

The tag 500 provides the advantage that the transformer 40 performs a dual function, namely to generate a supply potential to power the tag 500 and also to provide signal filtration.

In order to reduce manufacturing cost and increase compactness, the inventor has appreciated that it is desirable that a tag should only incorporate a single antenna for both receiving and emitting radiation. In Figure 6, there is shown a tag indicated by 600 incorporating the antenna 20 and operable to both emit radiation therefrom and receive radiation thererat. The tag 600 further comprises the circuits 30, 50, the transformer 40 and a transmitter (TX) 610. The terminals T_1, T_2 of the antenna 20 are connected to an input to the circuit 30 and to a signal earth respectively. An output from the circuit 30 is connected to the terminal P_1 of the transformer 40. The terminal P_2 of the transformer 40 is connected to the signal earth. An output B of the transmitter 610 is connected through a resistor R_1 to the terminal P_1 of the transformer 40. The secondary terminal S_1 of the transformer 40 is connected to the circuit 50 in a similar manner to the tag 10. Moreover, the transmitter 610 further comprises an output V which is coupled through a capacitor C_3 to the terminal T_1 of the antenna 20.

Operation of the tag 600 will now be described with reference to Figure 6. Initially, the transmitter 610 is not energised such that its output B is at a potential of the signal earth. Radiation having a carrier frequency of 1 GHz and modulated with a signal of 300 kHz is received at the antenna 20 which generates a corresponding signal across its terminals T_1, T_2. The signal is rectified to generate a 300 kHz signal across the capacitor C_1 which then passes to the primary region 42 of the transformer 40 to excite it into resonance. The transformer 40 generates a voltage-enhanced output signal at a frequency of 300 kHz at the

terminal S_1 which is subsequently demodulated by the circuit 50 to provide a potential for operating the transmitter 610.

The transmitter 610 functions to generate 100 μsec duration bursts of 1 GHz signal at a repetition rate of 2 Hz at its output V. When the transmitter 610 is about to emit a burst of 1 GHz radiation from the antenna 20, it firstly switches its output B to a potential approaching that supplied by the circuit 50 which reverse biases the diodes D_1, D_2 thereby disabling the circuit 30. The transmitter then outputs a burst signal through the capacitor C_3 to the antenna 20 from whence it is radiated as radiation. At the end of the burst signal, the transmitter switches its output B back to a potential of the signal earth so that the circuit 30 can continue to function to keep the capacitor C_2 charged until a next burst of radiation is to be emitted.

The tag 600 provides a further advantage that, because only one antenna 20 is required, the antenna 20 can, if required, be enlarged to occupy a majority of a major surface area of the tag 600. Such enlargement is not possible to achieve when two or more antennae are incorporated into a tag, each antenna requiring more than 50% of the major surface area of the tag 600.

It will be appreciated by one skilled in the art that modifications can be made to the tags 10, 300, 400, 500, 600 without departing from the scope of the invention.

For example, the tags 10, 300, 400, 500, 600 can be moulded into a plastic block rather than being implemented in card-like form as illustrated in Figure 2. The block is a more robust shape compared to a card, thereby enable the tags 10, 300, 400, 500, 600 in block form to

be deployed in rugged environments, for marking out a path in a smoke-filled burning building. A block is distinguishable from a card in that the ratio of the block's length, width and thickness dimensions are less than 1:3. A block form also includes a cuboid form, a pyramidal form and a near-spherical or spherical form.

As an alternative to using the diodes D1 to D4 in the tags 10, 300, 400, 500, 600, FETs functioning as asynchronous detectors may be employed. FETS operating in this made exhibit a voltage drop thereacross in the order of microvolts which is less than a forward bias voltage drop associated with diodes.

The tags 10, 300, 400, 500, 600 can be used as personnel wearable identity tags. They may be attached to items of merchandise and used in conjunction with an associated interrogating source to provide a merchandise anti-theft system.

The tags 10, 300, 400, 500, 600 can be used in a similar manner to "magic eye" reflectors used to delineate lanes on motorways; a plurality of the tags 10, 300, 400, 500, 600 can be employed as interrogatable markers for marking out a path. Such use is potentially valuable, for example, for defining routes for automatically guided robotic vehicles around manufacturing and storage sites. The guided vehicles can be equipped with interrogating sources which are sensitive to direction of radiation emitted from the tags 10, 300, 400, 500, 600 thereby determining direction of the tags 10, 300, 400, 500, 600 relative to the vehicles. Each tag 10, 300, 400, 500, 600 can be provided with its own unique signature code, thereby enabling the vehicle to determine its position along the path from the signature codes. Such a method of vehicle guidance is preferable to wire guided vehicle systems where greater installation cost can arise when installing guiding wires compared to distributing tags.

In the tags 10, 300, 400, 500, 600, the transformer 40 can be replaced by an alternative piezo-electric device operable to increase voltage. One example of an alternative piezo-electric device is a ceramic bi-morph in the form of an elongate member supported at one of its end and free the vibrate at its other end; such a bi-morph is capable of exhibiting a higher Q-factor than the transformer 40, thereby providing an enhanced voltage increase. Another example of an alternative piezo-electric device is a micromachined silicon device comprising an array of one or more suspended silicon cantilevers, each cantilever incorporating a deposited film piezo-electric transducer operable to generate a signal in response to vibration of the cantilever. The transducers are connected in series to add their signal voltages together to provide an overall output for the circuit 50. An excitation transducer operable to be driven by a drive signal from the circuit 30 is also incorporated for mechanically exciting the one or more cantilevers into vibration, preferable at resonance of the cantilevers. Silicon cantilevers are capable of exhibiting high resonance Q-factors approaching several million when operating in a miniature evacuated housing, thereby providing a considerable increase in signal voltage amplitude at the overall output compared to the drive signal. Silicon micromachining is a well known mass production process and involves fabrication of mechanical structures in silicon material using batch lithographic, deposition and etching techniques.

The tags 10, 300, 400, 500, 600 can be modified to include other types of electronic circuits, for example memory circuits and environmental sensors, for example radiation and chemical sensors. Such electronic circuits enable the tags to function as miniature personal data loggers which are personnel wearable and useable for monitoring the safety of personnel in working environments, for example in chemical laboratories where hazardous chemicals are

handled.

The tags 10, 300, 400, 500, 600 can be further miniaturised and adapted for inclusion within biological systems, for example for use as remotely controlled insulin dispensers, as heart-stimulating pace-makers or as artificial retina. Use of piezo-transformers powered from received modulated radiation avoids the need for batteries in the tags and thereby enables the tags to be implanted permanently within biological systems without needing to be periodically removed.

CLAIMS

1. A piezo-electric tag (10) including receiving means (20, 30) for receiving input radiation and generating a corresponding received signal, piezo-electric vibrating means (40, 50) for increasing voltage magnitude of the received signal to generate a supply potential and electronic circuit means (60) powerable by the supply potential.

2. A tag according to Claim 1 wherein the vibrating means (30, 40) comprises a piezo-electric transformer (40) incorporating mutually vibrationally coupled primary and secondary regions (42, 44), the transformer (40) operable to be excited into vibration by the received signal at the primary region (42) and to generate a corresponding output signal at the secondary region (44) for use in generating the supply potential.

3. A tag according to Claim 1 wherein the vibrating means (40) comprises a piezo-electric bi-morph operable to be excited into vibration by the received signal and to generate a corresponding output signal for use in generating the supply potential.

4. A tag according to Claim 1 wherein the vibrating means comprises a silicon micromachined device comprising an array of one or more resonant elements, each element incorporating an associated piezo-electric transducer operable to generate an element signal in response to vibration of its associated element, the transducers connected in series to add their element signals to provide an overall output from which the supply potential is generated, and driving means operable to be driven by

the received signal for stimulating the one or more elements into vibration and thereby generating the supply potential.

5. A tag according to Claim 4 wherein the resonant elements are operable at resonance to generate the supply potential.

6. A tag according to Claim 4 or 5 wherein the resonant elements are housed in an evacuated environment for increasing their resonance Q factor.

7. A tag according to any one of Claims 1 to 6 wherein the receiving means incorporates demodulating means (30) for demodulating modulation components present in the received radiation to generate the received signal.

8. A tag according to Claim 7 wherein the demodulating means (30) incorporates zero-bias Schottky diodes for demodulating the received radiation to generate the received signal.

9. A tag according to Claim 7 wherein the demodulating means incorporates transistors operable as synchronous demodulators for demodulating the received signal to generate the received signal.

10. A tag according to any preceding claim wherein the circuit means is operable to function in a class C mode for reducing tag power consumption.

11. A tag according to any one of Claims 1 to 10 wherein the receiving means (20, 310) incorporates first and second antennae (20, 310) for generating the received signal for exciting the vibrating means (40), the first antenna adapted (20) to respond to microwave radiation and the second antenna (310) adapted to respond to radiation having a carrier frequency corresponding to a resonant frequency of the vibrating means (40).

12. A tag according to any one of Claims 1 to 11 wherein the receiving means (20, 310, 410, 430) incorporates at least one of a metallic film dipole antenna, a loop antenna and a patch antenna for one or more of receiving and emitting radiation.

13. A tag according to any one or Claims 1 to 12 wherein the circuit means comprises responding means (64, 68, 70; 420, 430; 510, 520, 530) for emitting output radiation from the tag (10; 400; 500), the responding means powerable by the supply potential.

14. A tag according to Claim 13 wherein the vibrating means is operable to recover a clock component of Manchester bi-phase encoded radiation received at the tag and the responding means is operable to use the clock component to demodulate the encoded radiation to generate corresponding demodulated data for use in the tag.

15. A tag according to Claim 13 wherein the tag incorporates two antennae(20, 64), one antenna (20) for use in generating the received signal and the other (64) incorporated into the responding means (60) for at least one of emitting and receiving radiation.

16. A tag according to Claim 13 wherein the antennae are conductive metallic film dipole

antennae.

17. A tag according to any preceding claim in the form of a block.

18. A tag according to any one or Claims 1 to 16 in the form of a planar card (Fig. 2).

19. A tag according to Claim 18 wherein the card incorporates recesses (230, 240, 250, 260) for accommodating the receiving means, the vibrating means and the responding means.

20. A tag according to Claims 13 wherein the responding means is a transponder operable to receive input radiation to the tag and emit output radiation in response from the tag.

21. A tag according to Claim 20 wherein the transponder is operable to modulate the output radiation with a signature code by which the tag can be individually identified.

22. A tag (10) according to Claim 20 or 21 wherein the transponder incorporates a reflection amplifier (70) for amplifying the input radiation to generate the output radiation.

23. A tag (10) according to Claim 20, 21 or 22 wherein the transponder is operable in a pseudo-continuous mode and incorporates a delay line (68) for delaying the output radiation relative to the input radiation, thereby counteracting spontaneous oscillation from arising within the transponder from feedback therein.

24. A tag according to any preceding claim incorporating a metallic earthing plane for providing a common signal earth for the tag.

25. A tag according to any preceding claim adapted for implantation into a biological system and operable to at least one of monitor and stimulate the biological system.

26. A method of guiding vehicles along a path to a destination, the method comprising the steps of:

(a) distributing a plurality of tags according to any one of Claims 1 to 24 along the path and providing the vehicle with a direction sensitive interrogating source adapted to transpond with the tags;

(b) interrogating the tags from the source by emitting radiation to the tags and receiving radiation therefrom, thereby determining direction of the tags relative to the source and hence determining the path;

(c) moving the vehicle along the path; and

(d) repeating steps (b) and (c) until the vehicle reaches the destination.

27. A silicon micromachined device for receiving an input signal and generating a corresponding voltage magnitude enhanced output signal therefrom , the device comprising an array of one or more resonant elements, each element incorporating an associated piezo-electric transducer operable to generate an element signal in response to vibration of its associated element, the transducers connected in series to add their element signals to provide the output signal, and driving means operable to

be driven by the input signal for stimulating the one or more elements into vibration and thereby generating the output signal.

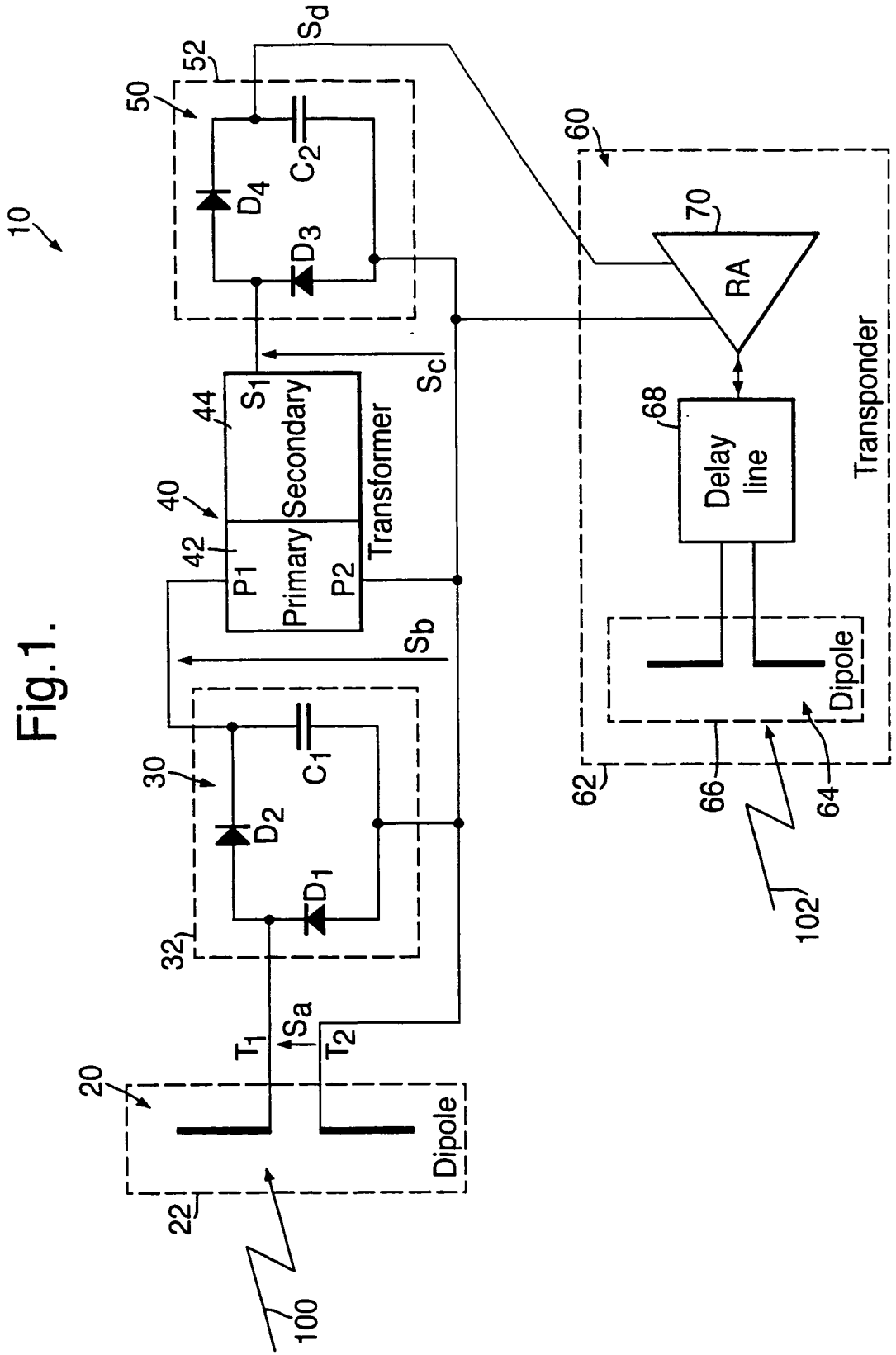
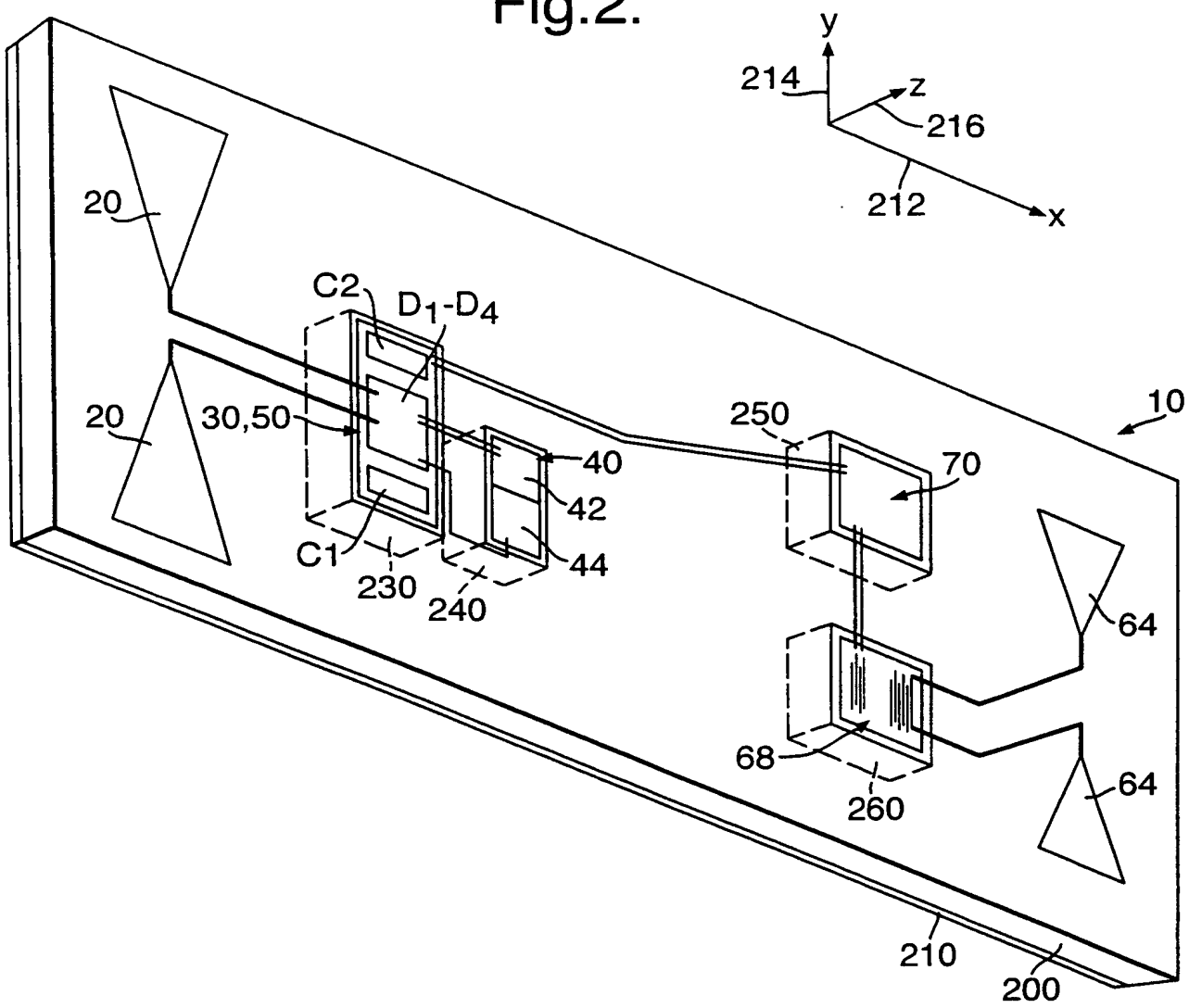

10
50
52
S_d
C_2
D_4
D_3
60
70
RA
Transponder
S_c
44
S_1
Secondary
Transformer
40
42
P1
Primary
P2
68
Delay line
S_b
Dipole
30
C_1
D_2
D_1
32
T_1
S_a
T_2
20
Dipole
22
100
62
66
64
102

Fig.1.

Fig.2.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214
z
216
212
x
20
20
C2
D1-D4
30,50
250
10
40
70
42
44
C1
230
240
64
68
260
64
210
200

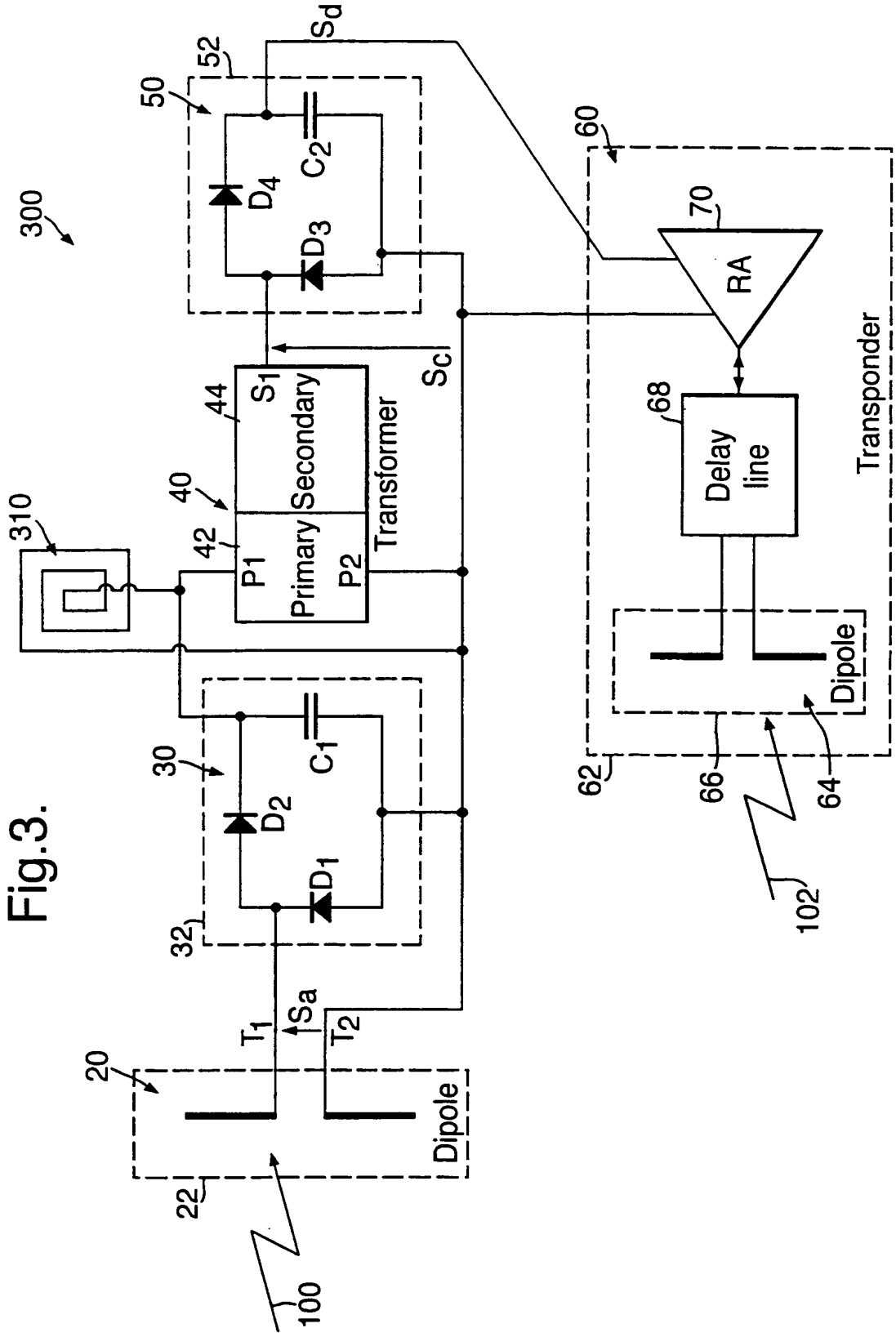
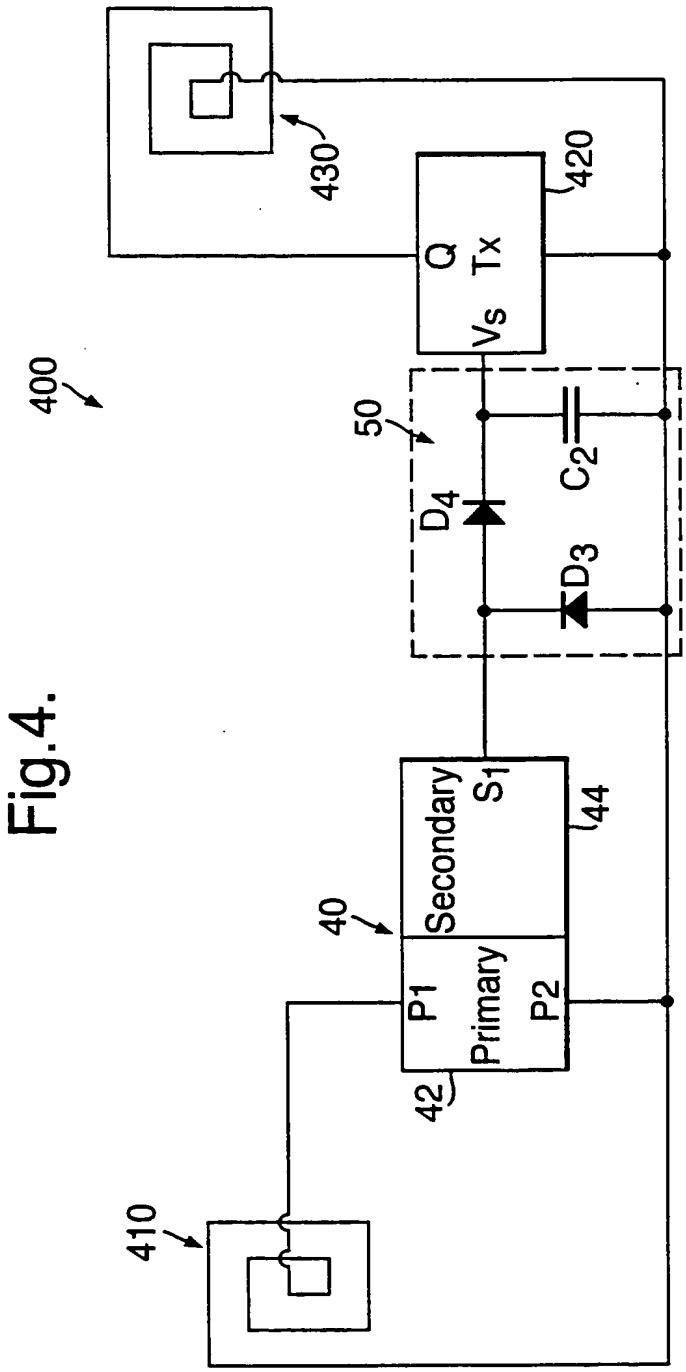

300
310
40
42
P1
Primary
P2
44
S1
Secondary
Transformer
Sc
Sd
50
52
D4
C2
D3
30
C1
D2
D1
32
Sa
T1
T2
20
Dipole
22
100
60
70
RA
Transponder
68
Delay line
Dipole
62
66
64
102

Fig.3.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430
420
Q
Tx
Vs
50
C2
D4
D3
Secondary
S1
44
40
P1
Primary
P2
42
410

Fig.4.

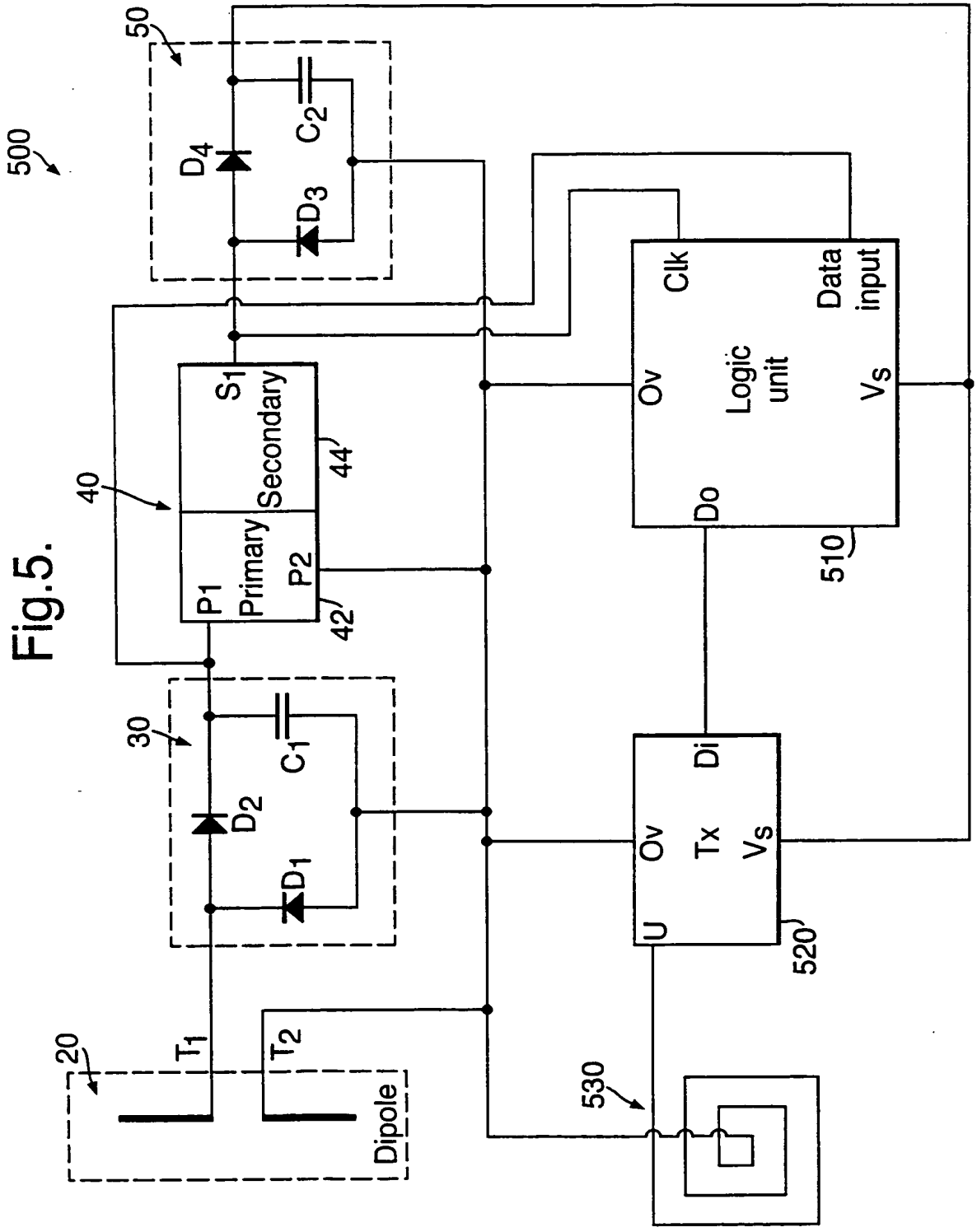
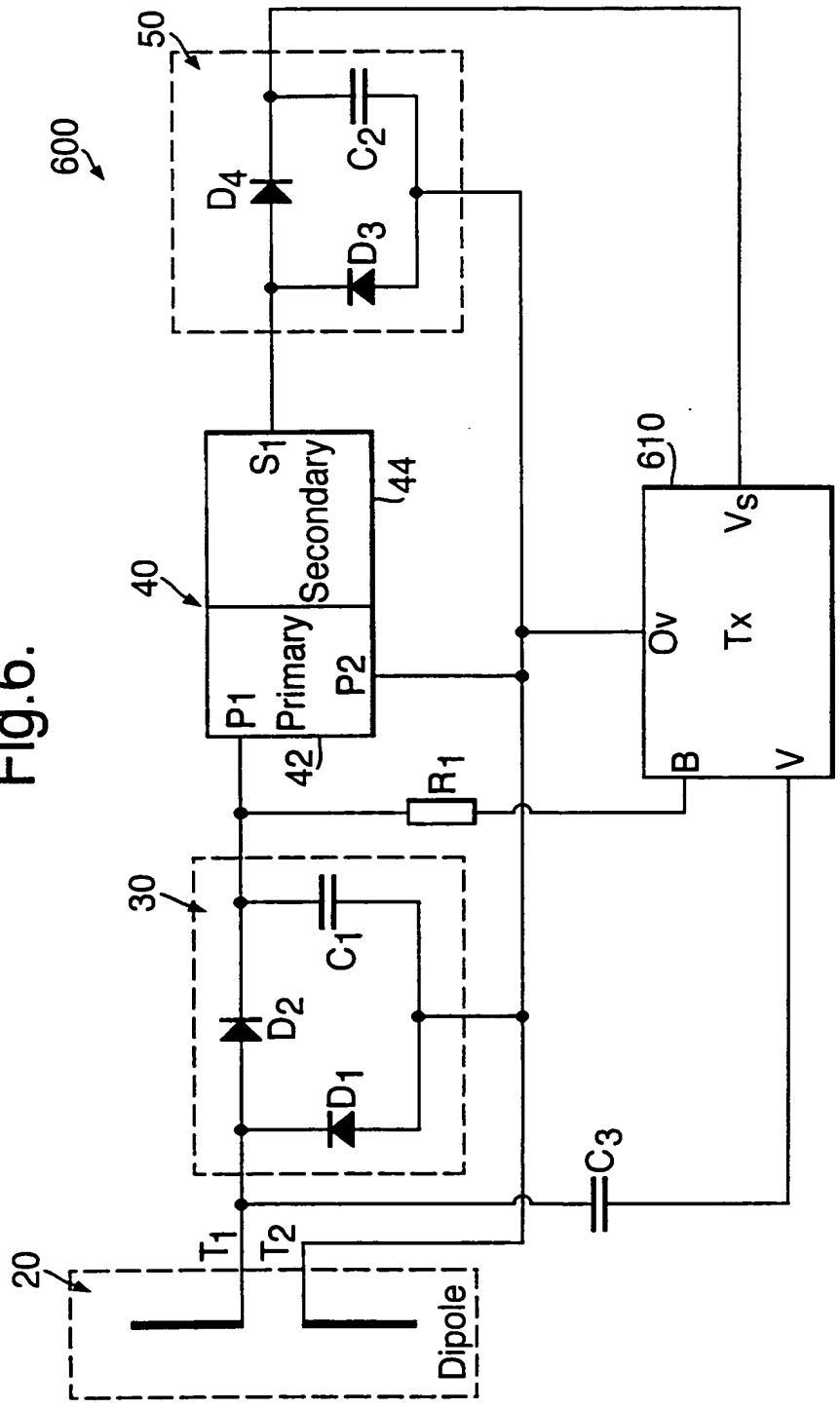

500
50
D_4
C_2
D_3
Clk
Data input
Ov
Logic unit
V_S
Do
510
40
S1
Secondary
44
P1
Primary
P2
42
30
C_1
D_2
D_1
Di
Ov
Tx
V_S
U
520
20
T_1
T_2
Dipole
530

Fig.5.

Fig.6.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50
C_2
D_4
D_3
S1
Secondary
44
40
P1
Primary
P2
42
610
Vs
Ov
Tx
B
V
R_1
30
C_1
D_2
D_1
C_3
T_1
T_2
20
Dipole

20845

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
P/61827/MRCE		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 00/ 02944	31/07/2000	29/07/1999
Applicant		
MARCONI CASWELL LIMITED		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/02944

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01S13/02 G06K19/07

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01S H01L G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 197 55 893 A (REIN CLAUS DR) 17 June 1999 (1999-06-17) column 3, line 52 -column 4, line 4 column 6, line 29 - line 49 column 8, line 14 - line 22 figures 1,2	1,13,17, 20
Y		3,10,12, 15,16, 18,19, 21,24-26
Y	EP 0 827 105 A (SIEMENS AG) 4 March 1998 (1998-03-04) column 3, line 39 - line 50; figure 1 column 4, line 49 -column 5, line 27; figure 8 column 1, line 12 - line 28	12,18, 19,21
A		20,22,23

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 December 2000	11/12/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bhalodia, A

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
[redacted]/GB 00/02944

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 196 08 515 C (SIEMENS AG) 5 June 1997 (1997-06-05) the whole document	3,24
Y	US 4 870 700 A (ORMANNS SIEGFRIED ET AL) 26 September 1989 (1989-09-26) column 3, line 15 -column 4, line 25; claims 5,11; figure 1	10,15
Y	US 4 951 057 A (NAGEL JON L) 21 August 1990 (1990-08-21)	16
A	the whole document	2,4,12, 23,27
Y	US 5 749 909 A (SCHROEPPEL EDWARD A ET AL) 12 May 1998 (1998-05-12) cited in the application column 5, line 6 - line 16	25
A	column 4, line 12 - line 19; figure 5 column 5, line 41 -column 6, line 38	4,27
Y	WO 98 35276 A (FMC CORP) 13 August 1998 (1998-08-13) page 3, line 20 -page 4, line 34; figure 1	26
A	US 5 457 447 A (GHAEM SANJAR ET AL) 10 October 1995 (1995-10-10) column 5, line 32 - line 67; figures 2,3 column 6, line 60 -column 7, line 15; figures 7,8	4,11,27

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
[redacted]/GB 00/02944

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19755893 A	17-06-1999	AU 2409099 A	28-06-1999
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		WO 9423542 A	13-10-1994

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P/61827/MRCE		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/02944	31/07/2000	29/07/1999
International Patent Classification (IPC) or national classification and IPC G01S13/02		
Applicant MARCONI CASWELL LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☒ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
07/02/2001	07.11.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Saur, E Telephone No. +49 89 2399 2741

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/02944

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-26 as originally filed

Claims, No.:

1-27 as originally filed

Drawings, sheets:

1-6 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

   ☐ restricted the claims.

   ☐ paid additional fees.

   ☐ paid additional fees under protest.

   ☒ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

   ☐ complied with.

   ☒ not complied with for the following reasons:
   see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

   ☐ all parts.

   ☒ the parts relating to claims Nos. 1-26.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	11-26
	No:	Claims	1
Inventive step (IS)	Yes:	Claims	11-26
	No:	Claims	1-10

Industrial applicability (IA) Yes: Claims 1-26
No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

ITEM IV
Lack of unity

1. It is considered that the present application relates to two different inventions as follows:

   1. A piezo-electric tag (claims 1 - 26)

   2. A silicon micromachined device (claim 27)

   Present independent claims 1 and 27 do not contain any **common** "special feature", as required by R. 13.2 PCT.

   Thus, the claims **do not set out unitary subject-matter,** Rule 13 PCT.

   Since the Applicant did not respond to the invitation to restrict the claims to a single invention or to pay an additional examination fee, the present report is restricted to claims 1 - 26, which appear to relate to the main invention, Art. 34 (3)(c) PCT.

ITEM V
Reasoned statement

1. The following documents (D) are referred to in this report:

   D1: DE 197 55 893 A (REIN CLAUS DR) 17 June 1999
   D2: US-A-5 457 447 (GHAEM SANJAR ET AL) 10 October 1995
   D3: EP-A-898 313 A1 (attached to this communication)

2. Since claim 1 does **not define** the electro-magnetic nature of the "input radiation", D1 (relating to a wire-less power supply of a tag using **acoustic** waves) is considered to anticipate the subject-matter of claim 1 (Art. 33 (2) PCT), as follows:

A piezo-electric tag (5) including receiving means (11) for receiving input radiation and generating a corresponding received signal, piezo-electric vibrating means (13, 14, 15) for increasing voltage magnitude of the received signal to generate a supply potential and electronic circuit means (9,12) powerable by the supply potential.

3. The present application relates to a tag being powered by external electro-magnetic radiation. Such type of tags (for example known from D2) are well-known in the art. Thus, even when claim 1 would refer to electro-magnetic "input radiation", the subject-matter of claim 1 could not be considered to involve an inventive step.

The additional features defined in claims 2 - 10 are considered to lack inventive step, Art. 33 (3) PCT, as follows:

3.1 Claim 2 relates to the use of a specific component, namely a piezo-electric transformer for voltage transformation in the power supply circuit of the tag. However, since such transformers are well-known in the art (see for example D3), the use of such a component in a tag is considered to be merely a matter of usual design. In particular, the favourable properties (high Q, high transformation ratio) of a piezo-electric transformer (D3, col. 13, l. 17 - col. 15, l. 6) make it a preferred choice for such an application.

3.2 The features of claims 3 - 5 are known from D2 (Fig. 7; col. 6, l. 60 - col. 7, l. 59).

3.3 Claim 6 relates to a measure of usual design.

3.4 The additional features of claims 7 - 9 concern measures of usual design which are either unavoidable (claim 7) or optional (claims 8 and 9) when the received modulation frequency is intended to excite the piezo-electric transformer.

3.5 The Class C operation mode of circuitry, as defined in claim 10, is well-known in the art.

4. The features of claim 11 are considered to be **not obvious**. The prior art does not provide a hint that a tag may be supplied with power, alternatively, either with microwave radiation, whereby the modulation frequency excites the piezo-electric transformer, or by coupling (via the planar coil 310) the low excitation frequency directly to the transformer.

However, the clarity defects of claim 11 should be rectified (see paragraph VIII, below).

The remaining dependent claims 12 - 26 are considered to be compliant with the requirements of Art. 33 PCT, if the features of a rectified claim 11 are included in a new claim 1.

ITEM VII
Defects in form or content

1. The two-part form according to Rule 6.3 (b) PCT appears to be appropriate for any independent claim. The preambles should be based on document D1 or D2 as closest prior art.

2. To meet the requirements of Rule 5.1 (a) (ii) and (iii) PCT, the introductory part of the description should include a reference to the documents D1, D2 and D3 and their disclosure.

2. According to Rule 6.2 (b) PCT the provision of reference signs of technical features mentioned in the claims should be more complete. Currently, some of these features are not provided with reference signs. It is considered that the inclusion of the missing reference signs would improve the intelligibility of the claims.

ITEM VIII
Clarity

1. Claim 11 lacks clarity due to an inconsistent use of terms, Art. 6 PCT. Reference numeral (310) does not refer to "second antenna". Instead, reference sign (310) refers to a **planar coil** for coupling the excitation frequency directly to the piezo-electric transformer.

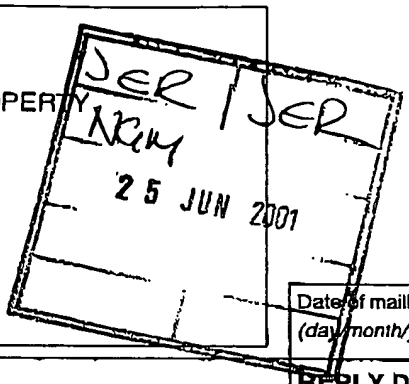
2. It is noted that the reference sign (320) on p. 17, lines 7, 8 and 10, is erroneous. It appears that reference sign (310) is meant.

PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

HOSTE, COLIN F.
MARCONI INTELLECTUAL PROPERTY
Waterhouse Lane
Chelmsford, Essex CM1 2QX
GRANDE BRETAGNE



PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing *(day/month/year)*	21.06.2001
Applicant's or agent's file reference: P/61827/MRCE	**REPLY DUE** **within 3 month(s)** from the above date of mailing

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/02944	31/07/2000	29/07/1999

International Patent Classification (IPC) or both national classification and IPC

G01S13/02

Applicant

MARCONI CASWELL LIMITED et al.

1. This written opinion is the **first** drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

I	☒	Basis of the opinion
II	☐	Priority
III	☐	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	☒	Lack of unity of invention
V	☒	Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	☐	Certain document cited
VII	☒	Certain defects in the international application
VIII	☒	Certain observations on the international application

3. The applicant is hereby **invited to reply** to this opinion.

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also: For an additional opportunity to submit amendments, see Rule 66.4.
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis.
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 29/11/2001.

Name and mailing address of the international preliminary examining authority:
European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer / Examiner
Saur, E

Formalities officer (incl. extension of time limits)
Bapisch, A
Telephone No. +49 89 2399 2262

I. Basis of the opinion

1. With regard to the **elements** of the international application (Replacement *sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed")*

Description, pages:

1-26 as originally filed

Claims, No.:

1-27 as originally filed

Drawings, sheets:

1-6 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rul 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure i the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation (Form PCT/IPEA/405) to restrict or pay additional fees, the applicant has:

☐ restricted the claims.

☐ paid additional fees.

☐ paid additional fees under protest.

☒ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with for the following reasons and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees:

3. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this opinion:

☐ all parts.

☒ the parts relating to claims Nos. 1-26.

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1
Inventive step (IS)	Claims	2-11
Industrial applicability (IA)	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

ITEM IV
Lack of unity

1. It is considered that the present application relates to two different inventions as follows:

   1. A piezo-electric tag (claims 1 - 26)

   2. A silicon micromachined device (claim 27)

   Present independent claims 1 and 27 do not contain any **common** "special feature", as required by R. 13.2 PCT.

   Thus, the claims **do not set out unitary subject-matter,** Rule 13 PCT.

   Since the Applicant did not respond to the invitation to restrict the claims to a single invention or to pay an additional examination fee, the present communication is restricted to claims 1 - 26, which appear to relate to the main invention, Art. 34 (3)(c) PCT.

ITEM V
Reasoned statement

1. The following documents (D) are referred to in this communication; the numbering will be adhered to in the rest of the procedure:

   D1: DE 197 55 893 A (REIN CLAUS DR) 17 June 1999
   D2: US-A-5 457 447 (GHAEM SANJAR ET AL) 10 October 1995
   D3: EP-A-898 313 A1 (attached to this communication)

2. Since claim 1 does **not define** the electro-magnetic nature of the "input radiation", D1 (relating to a wire-less power supply of a tag using **acoustic** waves) is considered to anticipate the subject-matter of claim 1 (Art. 33 (2) PCT), as follows:

A piezo-electric tag (5) including receiving means (11) for receiving input radiation and generating a corresponding received signal, piezo-electric vibrating means (13, 14, 15) for increasing voltage magnitude of the received signal to generate a supply potential and electronic circuit means (9,12) powerable by the supply potential.

3. The present application relates to a tag being powered by external electro-magnetic radiation. Such type of tags (for example known from D2) are well-known in the art. Thus, even when claim 1 would refer to electro-magnetic "input radiation", the subject-matter of claim 1 could not be considered to involve an inventive step.

The additional features defined in claims 2 - 10 are considered to lack inventive step, Art. 33 (3) PCT, as follows:

3.1 Claim 2 relates to the use of a specific component, namely a piezo-electric transformer for voltage transformation in the power supply circuit of the tag. However, since such transformers are well-known in the art (see for example D3), the use of such a component in a tag is considered to be merely a matter of usual design. In particular, the favourable properties (high Q, high transformation ratio) of a piezo-electric transformer (D3, col. 13, l. 17 - col. 15, l. 6) make it a preferred choice for such an application.

3.2 The features of claims 3 - 5 are known from D2 (Fig. 7; col. 6, l. 60 - col. 7, l. 59).

3.3 Claim 6 relates to a measure of usual design.

3.4 The additional features of claims 7 - 9 concern measures of usual design which are either unavoidable (claim 7) or optional (claims 8 and 9) when the received modulation frequency is intended to excite the piezo-electric transformer.

3.5 The Class C operation mode of circuitry, as defined in claim 10, is well-known in the art.

4. The features of claim 11 are considered to be **not obvious**. The prior art does not provide a hint that a tag may be supplied with power, alternatively, either with microwave radiation, whereby the modulation frequency excites the piezo-electric transformer, or by coupling (via the planar coil 310) the low excitation frequency directly to the transformer.

However, the clarity defects of claim 11 should be rectified (see paragraph VIII, below).

The remaining dependent claims 12 - 26 are considered to be compliant with the requirements of Art. 33 PCT, if the features of a rectified claim 11 are included in a new claim 1.

ITEM VII
Defects in form or content

1. The two-part form according to Rule 6.3 (b) PCT appears to be appropriate for any independent claim retained. The preambles should be based on document D1 or D2 as closest prior art.

2. To meet the requirements of Rule 5.1 (a) (ii) and (iii) PCT, the introductory part of the description should be amended to include a reference to the documents D1, D2 and D3 and their disclosure and should be made consistent with the new claims to be filed.

2. According to Rule 6.2 (b) PCT the provision of reference signs of technical features mentioned in the claims should be **completed**. Currently, some of these features are not provided with reference signs. It is considered that the inclusion of the missing reference signs would improve the intelligibility of the claims.

3. As a precaution, the attention of the Applicants is drawn to the fact that the application may not be amended in such a way that it contains subject matter which extends beyond the content of the application as filed (Article 34 (2) (b) sentence 2 PCT).

ITEM VIII
Clarity

1. Claim 11 lacks clarity due to an inconsistent use of terms, Art. 6 PCT. Reference numeral (310) does not refer to "second antenna". Instead, reference sign (310) refers to a **planar coil** for coupling the excitation frequency directly to the piezo-electric transformer.

2. It is noted that the reference sign (320) on p. 17, lines 7, 8 and 10, is erroneous. It appears that reference sign (310) is meant.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

HOSTE, COLIN F.
MARCONI INTELLECTUAL PROPERTY
Waterhouse Lane
Chelmsford, Essex CM1 2QX
GRANDE BRETAGNE

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	07.11.2001
Applicant's or agent's file reference P/61827/MRCE	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/02944	31/07/2000	29/07/1999

Applicant
MARCONI CASWELL LIMITED et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation mus contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Biermaier, R Tel.+49 89 2399-2487

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P/61827/MRCE		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/02944	31/07/2000	29/07/1999

International Patent Classification (IPC) or national classification and IPC
G01S13/02

Applicant
MARCONI CASWELL LIMITED et al.

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☒ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
07/02/2001	07.11.2001

Name and mailing address of the international preliminary examining authority:
European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer
Saur, E

Telephone No. +49 89 2399 2741

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/0294

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-26 as originally filed

Claims, No.:

1-27 as originally filed

Drawings, sheets:

1-6 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: ; which is:

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- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

☐ restricted the claims.

☐ paid additional fees.

☐ paid additional fees under protest.

☒ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

☐ complied with.

☒ not complied with for the following reasons:
see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

☐ all parts.

☒ the parts relating to claims Nos. 1-26.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 11-26
	No:	Claims 1
Inventive step (IS)	Yes:	Claims 11-26
	No:	Claims 1-10

Industrial applicability (IA) Yes: Claims 1-26
No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

ITEM IV
Lack of unity

1. It is considered that the present application relates to two different inventions as follows:

   1. A piezo-electric tag (claims 1 - 26)

   2. A silicon micromachined device (claim 27)

   Present independent claims 1 and 27 do not contain any **common** "special feature", as required by R. 13.2 PCT.

   Thus, the claims **do not set out unitary subject-matter,** Rule 13 PCT.

   Since the Applicant did not respond to the invitation to restrict the claims to a single invention or to pay an additional examination fee, the present report is restricted to claims 1 - 26, which appear to relate to the main invention, Art. 34 (3)(c) PCT.

ITEM V
Reasoned statement

1. The following documents (D) are referred to in this report:

   D1: DE 197 55 893 A (REIN CLAUS DR) 17 June 1999
   D2: US-A-5 457 447 (GHAEM SANJAR ET AL) 10 October 1995
   D3: EP-A-898 313 A1 (attached to this communication)

2. Since claim 1 does **not define** the electro-magnetic nature of the "input radiation", D1 (relating to a wire-less power supply of a tag using **acoustic** waves) is considered to anticipate the subject-matter of claim 1 (Art. 33 (2) PCT), as follows:

A piezo-electric tag (5) including receiving means (11) for receiving input radiation and generating a corresponding received signal, piezo-electric vibrating means (13, 14, 15) for increasing voltage magnitude of the received signal to generate a supply potential and electronic circuit means (9,12) powerable by the supply potential.

3. The present application relates to a tag being powered by external electro-magnetic radiation. Such type of tags (for example known from D2) are well-known in the art. Thus, even when claim 1 would refer to electro-magnetic "input radiation", the subject-matter of claim 1 could not be considered to involve an inventive step.

The additional features defined in claims 2 - 10 are considered to lack inventive step, Art. 33 (3) PCT, as follows:

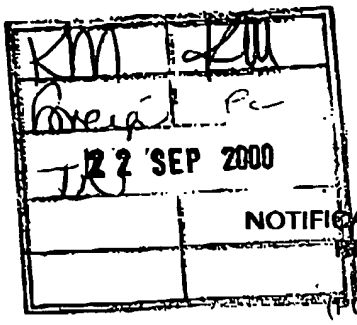
3.1 Claim 2 relates to the use of a specific component, namely a piezo-electric transformer for voltage transformation in the power supply circuit of the tag. However, since such transformers are well-known in the art (see for example D3), the use of such a component in a tag is considered to be merely a matter of usual design. In particular, the favourable properties (high Q, high transformation ratio) of a piezo-electric transformer (D3, col. 13, l. 17 - col. 15, l. 6) make it a preferred choice for such an application.

3.2 The features of claims 3 - 5 are known from D2 (Fig. 7; col. 6, l. 60 - col. 7, l. 59).

3.3 Claim 6 relates to a measure of usual design.

3.4 The additional features of claims 7 - 9 concern measures of usual design which are either unavoidable (claim 7) or optional (claims 8 and 9) when the received modulation frequency is intended to excite the piezo-electric transformer.

PATENT COOPERATION TREATY



PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

From the INTERNATIONAL BUREAU

To:

HOSTE, Colin, Francis
Marconi Intellectual Property
Waterhouse Lane
Chelmsford
Essex CM1 2QX
ROYAUME-UNI

Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
13 September 2000 (13.09.00)	
Applicant's or agent's file reference	**International application No.**
P/61827/MRCE	PCT/GB00/02944

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

MARCONI CASWELL LIMITED (for all designated States except US)
FORSTER, Ian, James (for US)

International filing date	:	31 July 2000 (31.07.00)
Priority date(s) claimed	:	29 July 1999 (29.07.99)
Date of receipt of the record copy by the International Bureau	:	23 August 2000 (23.08.00)
List of designated Offices	:	

AP :GH,GM,KE,LS,MW,MZ,SD,SL,SZ,TZ,UG,ZW
EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
National :AE,AG,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BY,BZ,CA,CH,CN,CR,CU,CZ,DE,DK,DM,DZ,EE,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,MZ,NO,NZ,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,US,UZ,VN,YU,ZA,ZW

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase
- [ ] confirmation of precautionary designations
- [X] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

Eugénia Santos

Telephone No. (41-22) 338.83.38

INFORMATION ON TIME LIMITS FOR ENTERING THE NATIONAL PHASE

The applicant is reminded that the "national phase" must be entered before each of the designated Offices indicated in the Notification of Receipt of Record Copy (Form PCT/IB/301) by paying national fees and furnishing translations, as prescribed by the applicable national laws.

The time limit for performing these procedural acts is **20 MONTHS** from the priority date or, for those designated States which the applicant elects in a demand for international preliminary examination or in a later election, **30 MONTHS** from the priority date, provided that the election is made before the expiration of 19 months from the priority date. Some designated (or elected) Offices have fixed time limits which expire even later than 20 or 30 months from the priority date. In other Offices an extension of time or grace period, in some cases upon payment of an additional fee, is available.

In addition to these procedural acts, the applicant may also have to comply with other special requirements applicable in certain Offices. **It is the applicant's responsibility** to ensure that the necessary steps to enter the national phase are taken in a timely fashion. Most designated Offices do not issue reminders to applicants in connection with the entry into the national phase.

For detailed information about the procedural acts to be performed to enter the national phase before each designated Office, the applicable time limits and possible extensions of time or grace periods, and any other requirements, see the relevant Chapters of Volume II of the PCT Applicant's Guide. Information about the requirements for filing a demand for international preliminary examination is set out in Chapter IX of Volume I of the PCT Applicant's Guide.

GR and ES became bound by PCT Chapter II on 7 September 1996 and 6 September 1997, respectively, and may, therefore, be elected in a demand or a later election filed on or after 7 September 1996 and 6 September 1997, respectively, regardless of the filing date of the international application. (See second paragraph above.)

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

CONFIRMATION OF PRECAUTIONARY DESIGNATIONS

This notification lists only specific designations made under Rule 4.9(a) in the request. It is important to check that these designations are correct. Errors in designations can be corrected where precautionary designations have been made under Rule 4.9(b). The applicant is hereby reminded that any precautionary designations may be confirmed according to Rule 4.9(c) before the expiration of 15 months from the priority date. If it is not confirmed, it will automatically be regarded as withdrawn by the applicant. There will be no reminder and no invitation. Confirmation of a designation consists of the filing of a notice specifying the designated State concerned (with an indication of the kind of protection or treatment desired) and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.

REQUIREMENTS REGARDING PRIORITY DOCUMENTS

For applicants who have not yet complied with the requirements regarding priority documents, the following is recalled.

Where the priority of an earlier national, regional or international application is claimed, the applicant must submit a copy of the said earlier application, certified by the authority with which it was filed ("the priority document") to the receiving Office (which will transmit it to the International Bureau) or directly to the International Bureau, before the expiration of 16 months from the priority date, provided that any such priority document may still be submitted to the International Bureau before that date of international publication of the international application, in which case that document will be considered to have been received by the International Bureau on the last day of the 16-month time limit (Rule 17.1(a)).

Where the priority document is issued by the receiving Office, the applicant may, instead of submitting the priority document, request the receiving Office to prepare and transmit the priority document to the International Bureau. Such request must be made before the expiration of the 16-month time limit and may be subjected by the receiving Office to the payment of a fee (Rule 17.1(b)).

If the priority document concerned is not submitted to the International Bureau or if the request to the receiving Office to prepare and transmit the priority document has not been made (and the corresponding fee, if any, paid) within the applicable time limit indicated under the preceding paragraphs, any designated State may disregard the priority claim, provided that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity to furnish the priority document within a time limit which is reasonable under the circumstances.

Where several priorities are claimed, the priority date to be considered for the purposes of computing the 16-month time limit is the filing date of the earliest application whose priority is claimed.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

HOSTE, Colin, Franci
Marconi Intellectual Property
Waterhouse Lane
Chelmsford
Essex CM1 2QX
ROYAUME-UNI

Forensic PC
8 DEC 2000

Date of mailing (day/month/year) 13 November 2000 (13.11.00)	
Applicant's or agent's file reference P/61827/MRCE -FWLOOPCIP AS	**IMPORTANT NOTIFICATION**
International application No. PCT/GB00/02944	International filing date (day/month/year) 31 July 2000 (31.07.00)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 29 July 1999 (29.07.99)
Applicant MARCONI CASWELL LIMITED et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An asterisk(*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The letters "NR" appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
29 July 1999 (29.07.99)	9917856.8	GB	13 Sept 2000 (13.09.00)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
Somsak Thiphrakesone

Telephone No. (41-22) 338.83.38

003851958

AP noted on computer
Foreign FC
21 DEC 2001
NGm

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

HOSTE, Colin, Francis
Marconi Intellectual Property
Waterhouse Lane
Chelmsford
Essex CM1 2QX
ROYAUME-UNI

Date of mailing (day/month/year)
13 December 2001 (13.12.01)

IMPORTANT NOTIFICATION

Applicant's or agent's file reference
P/61827/~~MRCE~~ DSIC

International application No.
PCT/GB00/02944

International filing date (day/month/year)
31 July 2000 (31.07.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address
MARCONI CASWELL LIMITED
One Bruton Street
London W1X 8AQ
United Kingdom

State of Nationality: GB
State of Residence: GB
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [X] the name [X] the address [ ] the nationality [ ] the residence

Name and Address
MARCONI DATA SYSTEMS LTD
153 Dixons Hill Road
Welham Green
Hatfield
Hertfordshire AL9 7JE
United Kingdom

State of Nationality: GB
State of Residence: GB
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer
S. Buttay

Telephone No.: (41-22) 338.83.38

0045367

Form PCT/IB/308 (March 1994)

PATENT COOPERATION TREATY

PCT

From the INTERNATIONAL BUREAU

To:
HOSTE, Colin, Francis
Marconi Intellectual Property
Waterhouse Lane
Chelmsford
Essex CM1 2QX
ROYAUME-UNI

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

Date of mailing (day/month/year) 08 February 2001 (08.02.01)	
Applicant's or agent's file reference P/61827/MRCE	**IMPORTANT NOTICE**
International application No. PCT/GB00/02944	**International filing date** (day/month/year) 31 July 2000 (31.07.00)
Priority date (day/month/year) 29 July 1999 (29.07.99)	
Applicant MARCONI CASWELL LIMITED et al	

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AU,KP,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AE,AG,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,BZ,CA,CH,CN,CR,CU,CZ,DE,DK,DM,DZ,EA,EE,EP,ES, FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK, MN,MW,MX,MZ,NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   08 February 2001 (08.02.01) under No. WO 01/09640

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a **demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
J. Zahra

Telephone No. (41-22) 338.83.38

Continuation of Form PCT/IB/30

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

Date of mailing (day/month/year)	IMPORTANT NOTICE
08 February 2001 (08.02.01)	
Applicant's or agent's file reference	**International application No.**
P/61827/MRCE	PCT/GB00/02944

The applicant is hereby notified that, at the time of establishment of this Notice, the time limit under Rule 46.1 for making amendments under Article 19 has not yet expired and the International Bureau had received neither such amendments nor a declaration that the applicant does not wish to make amendments.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 22 March 2001 (22.03.01)	
International application No. PCT/GB00/02944	**Applicant's or agent's file reference** P/61827/MRCE
International filing date (day/month/year) 31 July 2000 (31.07.00)	**Priority date** (day/month/year) 29 July 1999 (29.07.99)
Applicant FORSTER, Ian, James	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

07 February 2001 (07.02.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Olivia TEFY
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

From the INTERNATIONAL BUREAU

To:

HOSTE, Colin, Francis
Marconi Intellectual Property
Waterhouse Lane
Chelmsford
Essex CM1 2QX
ROYAUME-UNI

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

Date of mailing (day/month/year)
13 December 2001 (13.12.01)

Applicant's or agent's file reference
P/61827/MRCE

IMPORTANT NOTIFICATION

International application No.
PCT/GB00/02944

International filing date (day/month/year)
31 July 2000 (31.07.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address

MARCONI CASWELL LIMITED
One Bruton Street
London W1X 8AQ
United Kingdom

State of Nationality: GB
State of Residence: GB
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [X] the name [X] the address [ ] the nationality [ ] the residence

Name and Address

MARCONI DATA SYSTEMS LTD
153 Dixons Hill Road
Welham Green
Hatfield
Hertfordshire AL9 7JE
United Kingdom

State of Nationality: GB
State of Residence: GB
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

S. Buttay

Telephone No.: (41-22) 338.83.38